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NORMAL BLOOD CHEMISTRY VALUES FOR LABORATORY ANIMALS ANALYZED BY THE SEQUENTIAL MULTIPLE CHANNEL ANALYZER COMPUTER (SMAC-20)

By

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February 1979

U.S. ARMY AEROMEDICAL RESEARCH LABORATORY
FORT RUCKER, ALABAMA 36362

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Sequential Multiple Channel Analyzer Computers are rapidly becoming common diagnostic tools of both physicians and veterinarians in medical and research facilities. This increased use requires a reappraisal of normal serum values presently established for standard diagnostic tests. This report establishes normal serum values for laboratory animals to include dogs, mice, miniature swine and horses. In addition, comparisons are made between age, sex, and age and sex in the dog to show probable discrepancies in the use of standard normal values.

PREFACE

This work was done under Program Element 6.27.73.A, Project 3E162773A819, Work Unit 007.

In conducting the research described in this report, the investigator(s) adhered to the "Guide for Laboratory Animal Facilities and Care," as promulgated by the Committee on the Guide for Laboratory Animal Resources, National Academy of Sciences-National Research Council.

The authors wish to thank Ms. Carolyn Harris, Ms. Gail Jay and Ms. Carolyn Johnson for the preparation of the report and SP5 Michael Nelson and Mr. John Sowell for the preparation of the figures. The technical assistance of SP5 James Faber, SP4 Michael Cevasco, and SP5 Caela Gargano is also acknowledged. Special thanks to Ms. Doris Hirsch and Mr. Chuck Snow for their operation of the SMAC-20.

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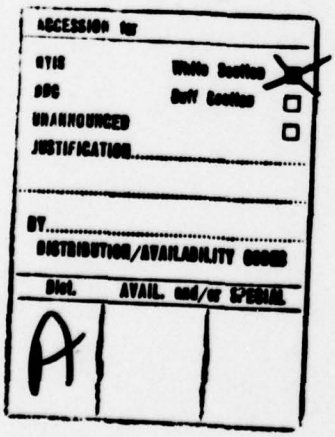

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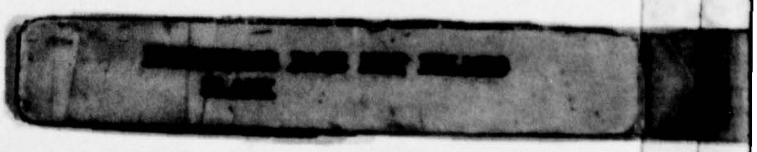

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INTRODUCTION

Multiple channel serum analyzer capabilities are available today in many community and research medical facilities. Normal serum values for laboratory animals have not been established to date using the Sequential Multiple Channel Analyzer Computer (SMAC-20).

The advantages of multiple channel tests as given by Galen[1] include:

1. It provides additional information in the form of an extra test. Typical screening profile involves both "first-order" and "second-order" tests. When the first-order test shows the existence of some abnormality, a second-order test is usually given to supply additional information and to confirm the diagnosis. The SMAC-20 provides both tests at the same time, thus speeding diagnosis.

2. It provides additional sampling without additional sample labeling thus eliminating potential sources of error.

3. Technician time, analysis time, and reporting time are saved.

The blood chemistry values presented in this report utilize the US Army Aeromedical Research Laboratory's (USAARL) animal colonies. Animals from the Fort Rucker area were used in establishing SMAC blood chemistry values for dogs because USAARL's colony lacked a sufficient number.

This study was initiated to establish normal values for the USAARL animal colony. Review of available literature provided only partial studies of normal blood chemistry values using automated analysis. The data in this report now provides the first available normal values for dogs, miniature swine, mice, and horses analyzed by the Sequential Multiple Channel Analyzer Computer.

MATERIALS AND METHODS

Blood samples for SMAC-20 analysis were collected from 126 dogs, 37 horses, 39 Swiss webster albino mice, and 10 Pittman-Moore miniature swine. All animals were examined by a veterinarian to assure normality and health.

Standard restraint procedures were used during blood withdrawal from the cephalic and external jugular veins of the dogs and horses, respectively, using 10 milliliter (mℓ) vacutainers. In order to facilitate the venipuncture of the anterior vena cava in swine,[2] a trough device, Figure 1, was used for restraint. Once restrained the entire trough was inverted, placing the pig in dorsal recumbency. The mice

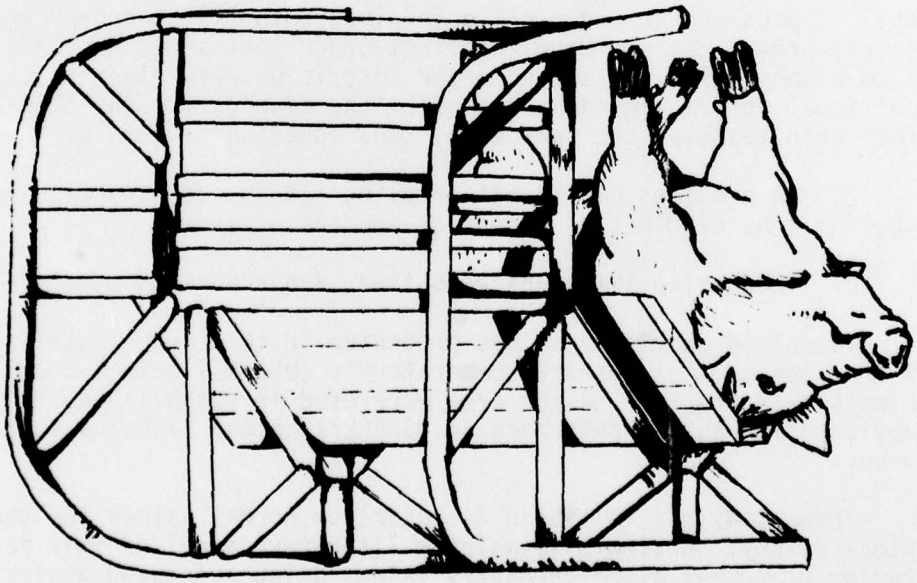

FIGURE 1. Illustrates position of the pig and the restraint mechanism used to collect blood via anterior vena cava.

were anesthetized with halothane, then placed in dorsal recumbency with appendages secured to a small mice restraint board, Figure 2. Blood was then withdrawn from the brachial vessels.[3]

All blood samples were collected in the morning at 0900 hours ± 2 hours following a 24-hour fast. The blood was allowed to clot for 30 minutes at room temperature prior to centrifuging and separation of serum from the clot. Serum was stored at 0°C for no more than 1 week before analysis.

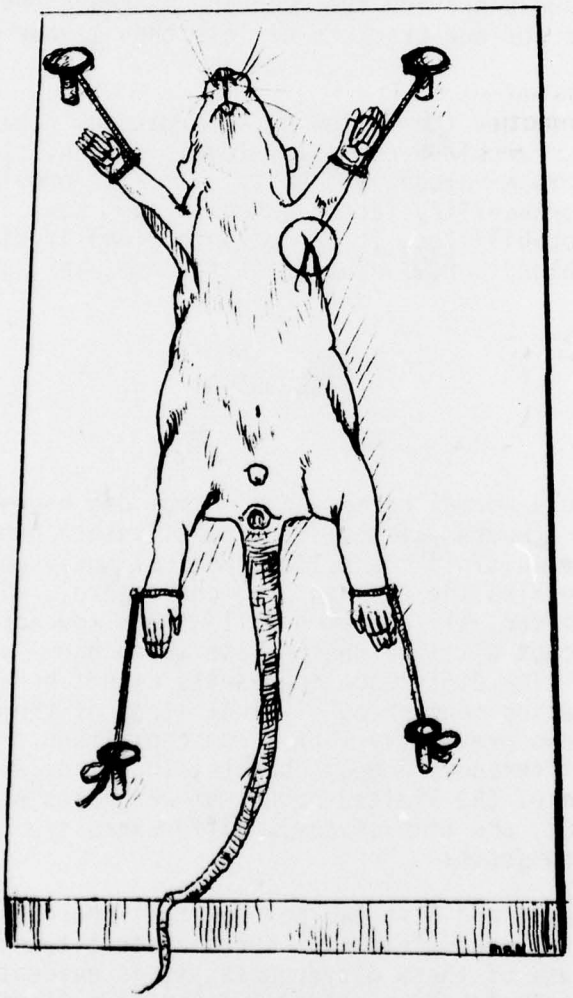

FIGURE 2. Shows a mouse restrained for blood collection from the brachial vessels. The circle represents the collection site.

RESULTS

Tables 1-5 provide a summary of the SMAC-20 profiles. Evaluation of canine blood chemistry samples utilized two parameters to evaluate differences--age and sex.

Tables 4 and 5 provide the mean and standard deviation for male and female dogs for age brackets of less than 1 year to greater than 5 years.

Table 6 provides the following information, regardless of age or sex of the dog, for blood chemistry levels: mean, standard deviation, maximum and minimum values, and units. It also provides the veterinarian with a probability factor based on age, sex, and age and sex. Using these probabilities, it can be determined if significant differences of each blood serum value exist for age, sex, and age and sex.

DISCUSSION

Values for a normal horse and a normal dog have been presented previously for a number of the serum constituents presented in this paper for other multiple channel biochemical analyses. Of those in the horse, only alkaline phosphotase, cholesterol, glucose, SGOT, and triglyceride differ, all of which fall within the normal range presented here except alkaline phosphotase which had a value below our minimum range. The difference in results cannot be explained due to limited information concerning clinical state of the subject. However, it has been shown previously that serum constituents will vary with time of day, differences among subjects, location, and instrumentation.[4] Because of the limited number of variables within mice (age, sex, environment, and time of day), differences are attributed to variations within subjects.

From Tables 4 and 5 it can be seen that there is a significant difference in the serum levels of certain constituents based on age and sex. Because of these differences, it is evident that age and sex should be considered before clinical laboratory findings of serum constituent values are accepted as normal or abnormal. The range found in this study indicates the difficulty in differentiating the normal

from abnormal for a specific patient. It further implies that the most common approach to establishing normals for clinical laboratory tests, as the mean value plus or minus two standard deviations, is not justifiable for an individual patient.[5]

CONCLUSION

Under a standard laboratory environment, USAARL established individual normal values for the laboratory's animals with only feeding controlled. Due to the various intrinsic and extrinsic factors that affect serum constituent levels, it is becoming more and more advantageous, where possible, for the animal/patient's own normal values to be determined on a control rather than a range of normal values.

The use of the SMAC-20 is of importance in both research and clinical medicine. The SMAC can provide the practicing clinical and research veterinarian with two types of profiles--disease specific and multiphasic screening. The normal range of biochemical determinations has been developed for military and civilian research animal laboratories with the advanced state of the art Sequential Multiple Analyzer Computer. This study provides a ready reference for those military and civilian research facilities initiating animal programs.

TABLE 1

SMAC-20 PROFILE OF 36 FASTED SWISS WEBSTER ALBINO MICE

Parameter	Mean		Standard Deviation	Maximum	Minimum	Units
Glucose	181.2	±	32.2*	222.0	125.0	mg/dl
BUN	21.5	±	2.6	29.0	18.0	mg/dl
Creatinine	0.5	±	0.6	0.6	0.4	mg/dl
Na	150.2	±	2.7	155.0	144.0	meq/L
K	7.2	±	9.0	8.5	5.6	meq/L
Cl	114.1	±	2.1	118.0	112.0	meq/L
CO_2	8.5	±	1.8	12.0	6.0	meq/L
Uric Acid	3.8	±	8.1	4.9	2.0	mg/dl
Calcium	9.8	±	4.4	10.4	9.0	mg/dl
Phosphorus	8.4	±	6.1	9.5	7.4	mg/dl
Iron	219.3	±	35.3	290.0	177.0	mcg/dl
Total Protein	5.6	±	2.7	6.2	5.1	g/dl
Albumin	3.1	±	1.3	3.2	2.8	g/dl
Alk. Phos.	90.0	±	10.7	111.0	75.0	U/L
Total Billir.	0.1	±	0.2	0.1	0.1	mg/dl
Cholesterol	98.2	±	9.1	121.0	86.0	mg/dl
Trigly.	42.6	±	16.9	70.0	17.0	mg/dl
SGOT	2024.1	±	2918.9	6326.0	96.0	U/L
LDH	463.5	±	166.1	766.0	220.0	U/L
CPK	1856.3	±	1061.2	3538.0	245.0	U/L

*Mean ±/S.D.

TABLE 2

SMAC-20 PROFILE OF 10 FASTED PITTMAN MOORE MINIATURE SWINE

Parameter	Mean		Standard Deviation	Maximum	Minimum	Units
Glucose	160.9	±	54.7*	268.0	111.0	mg/dl
BUN	11.3	±	2.8	17.0	9.0	mg/dl
Creatinine	16.9	±	2.4	21.0	14.0	mg/dl
Na	151.5	±	1.9	154.0	149.0	meq/l
K	33.0	±	2.4	37.0	29.0	meq/l
Cl	107.4	±	2.5	111.0	104.0	meq/l
CO_2	15.4	±	4.7	21.0	7.0	meq/l
Uric Acid	1.1	±	0.4	2.0	1.0	mg/dl
Calcium	113.8	±	4.9	121.0	107.0	mg/dl
Phosphorus	52.9	±	5.4	60.0	46.0	mg/dl
Iron	187.4	±	20.5	220.0	161.0	mcg/dl
Total Protein	85.3	±	2.9	91.0	82.0	g/dl
Albumin	49.5	±	2.9	54.0	46.0	g/dl
Alk. Phos.	18.3	±	9.3	34.0	10.0	U/L
Total Billir.	6.2	±	1.0	7.0	5.0	mg/dl
Cholesterol	90.5	±	10.6	108.0	75.0	mg/dl
Trigly.	48.4	±	47.2	140.0	6.0	mg/dl
SGOT	59.5	±	6.7	69.0	49.0	U/L
LDH	348.3	±	38.4	402.0	290.0	U/L
CPK	275.6	±	182.3	612.0	107.0	U/L

*mean ±/S.D.

TABLE 3

SMAC-20 PROFILE OF 38 FASTED HORSES

Parameter	Mean		Standard Deviation	Maximum	Minimum	Units
Glucose	98.5	±	16.9	161.0	61.0	mg/dl
BUN	12.2	±	3.3	22.0	8.0	mg/dl
Creatinine	1.8	±	3.8	2.7	1.1	mg/dl
Na	139.7	±	1.9	144.0	136.0	meq/l
K	4.0	±	5.5	5.2	2.3	meq/l
Cl	106.6	±	2.4	110.0	100.0	meq/l
CO_2	25.8	±	2.1	30.0	21.0	meq/l
Uric Acid	0.3	±	1.8	0.6	0.0	mg/dl
Calcium	12.6	±	5.3	13.5	11.0	mg/dl
Phosphorus	3.3	±	8.4	6.9	2.2	mg/dl
Iron	164.2	±	35.1	236.0	108.0	mcg/dl
Total Protein	7.0	±	5.6	8.0	5.3	g/dl
Albumin	3.5	±	3.7	4.0	1.8	g/dl
Alk. Phos.	238.0	±	141.3	999.0	143.0	U/L
Total Billir.	1.1	±	55.4	2.8	1.0	mg/dl
Cholesterol	101.0	±	16.4	175.0	79.0	mg/dl
Trigly.	27.0	±	24.1	11.5	0.0	mg/dl
SGOT	207.0	±	53.3	375.0	110.0	U/L
LDH	271.0	±	54.3	396.0	161.0	U/L
CPK	104.0	±	142.5	934.0	42.0	U/L

*Mean ±/S.D.

TABLE 4

SMAC-20 PROFILE OF FASTED FEMALE DOGS

	< 1 Yr.		1-2 Yrs.		3-4 Yrs.		5 Yrs. and Above	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Glucose	103.1 ±	18.4*	93.6	17.9	10.0	13.8	99.6	11.1
BUN	15.5 ±	7.6	15.6	4.5	18.6	9.6	15.0	6.4
Creatinine	0.8 ±	1.7	1.0	1.8	1.0	2.1	0.9	2.2
Na	142.9 ±	4.0	146.0	3.9	146.0	3.0	148.0	3.1
K	4.9 ±	4.3	4.7	3.5	4.7	4.6	4.7	4.1
Cl	110.8 ±	4.8	113.9	4.3	113.3	3.8	113.9	5.4
CO_2	20.3 ±	2.5	20.2	2.6	19.7	3.1	21.5	3.6
Uric Acid	1.7 ±	1.7	2.2	1.8	2.4	1.7	1.8	2.0
Calcium	10.6 ±	4.6	10.7	6.3	10.1	19.5	10.1	6.9
Phosphorus	6.5 ±	4.0	4.4	9.9	4.0	7.2	3.5	9.0
Iron	156.9 ±	93.3	179.9	67.1	159.2	86.1	177.4	58.6
Total Protein	6.1 ±	10.8	6.4	7.0	6.4	16.4	6.9	6.7
Albumin	2.8 ±	6.1	3.1	4.8	3.1	4.9	2.9	3.8
Alk. Phos.	97.3 ±	64.2	56.0	25.4	40.9	22.4	52.1	35.1
Total Billir.	0.4 ±	1.5	1.2	4.2	0.3	0.9	0.8	2.5
Cholesterol	152.7 ±	23.7	180.8	47.8	202.3	89.9	155.5	25.3
Trigly.	48.7 ±	22.9	58.1	33.1	51.2	44.7	46.7	13.9
SGOT	30.0 ±	8.4	31.9	19.6	31.5	18.1	150.2	302.1
LDH	132.7 ±	142.8	94.1	66.5	79.9	69.7	92.4	50.3
CPK	115.6 ±	51.2	84.4	114.7	48.5	39.1	56.3	40.9

*Mean ±/S.D.

TABLE 5

SMAC-20 PROFILE OF FASTED MALE DOGS

	< 1 Yr.		1-2 Yrs.		3-4 Yrs.		5 Yrs. and Above	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Glucose	104.2 ±	21.3*	99.6	14.4	89.3	11.7	105.9	15.3
BUN	15.8 ±	5.0	18.9	6.9	19.5	5.7	17.2	15.0
Creatinine	0.8 ±	1.4	1.2	5.6	1.1	2.3	1.1	4.2
Na	143.3 ±	5.3	146.6	2.6	146.5	2.2	146.3	4.9
K	4.6 ±	3.9	4.7	5.0	4.7	3.5	4.7	4.3
Cl	112.1 ±	4.9	115.2	3.3	114.7	1.8	115.7	5.6
CO_2	20.3 ±	2.8	20.8	2.4	21.3	2.1	18.4	4.9
Uric Acid	1.7 ±	2.6	2.1	1.8	2.9	2.2	1.7	1.9
Calcium	10.7 ±	7.8	10.4	3.6	10.2	6.2	10.1	8.9
Phosphorus	7.3 ±	13.8	4.7	11.7	4.0	8.2	3.8	8.1
Iron	174.8 ±	97.7	192.4	80.2	145.6	38.6	125.4	41.4
Total Protein	5.4 ±	10.7	6.3	7.0	6.9	10.1	6.9	10.1
Albumin	3.0 ±	3.2	3.0	4.5	2.8	5.3	2.8	6.0
Alk. Phos.	137.3 ±	2.0	51.4	31.8	34.3	15.5	42.7	17.9
Total Billir.	0.2 ±	0.8	1.4	3.3	0.8	2.6	---	---
Cholesterol	154.6 ±	24.0	156.0	29.6	150.9	22.5	164.4	38.4
Trigly.	47.2 ±	21.8	46.5	26.8	34.2	9.3	35.6	17.4
SGOT	45.2 ±	35.5	31.1	13.9	27.1	14.6	31.8	33.6
LDH	154.5 ±	133.4	106.9	96.1	77.3	53.2	89.7	57.0
CPK	168.8 ±	113.1	64.1	43.5	46.3	20.9	78.4	83.4

*Mean ±/S.D.

TABLE 6

SMAC-20 PROFILE OF 126 FASTED DOGS

Serum Constituent	Mean		Standard Deviation	Maximum	Minimum	Units	Prob. of Sign. Dif. Based on Age	Within Ages < 1 Yr. Sex	Age and Sex
Glucose	98.9	±	16.3*	147.0	57.0	mg/dl	0.127	0.635	0.834
BUN	17.1	±	7.7	58.0	6.0	mg/dl	0.336	0.216	0.636
Creatinine	1.0	±	0.3	3.6	0.6	mg/dl	0.003	0.117	0.665
Na	145.7	±	3.9	154.0	130.0	meq/l	0.001	0.784	1.000
K	4.7	±	0.4	6.3	3.9	meq/l	0.154	0.860	0.996
Cl	113.7	±	4.4	126.0	99.0	meq/l	0.012	0.067	0.045
CO_2	20.3	±	2.9	28.0	8.0	meq/l	0.935	0.837	0.907
Uric Acid	0.2	±	0.2	0.8	0.0	mg/dl	0.269	0.976	0.699
Calcium	10.4	±	1.0	12.0	2.4	mg/dl	0.041	0.836	0.505
Phosphorus	4.8	±	1.6	9.2	2.2	mg/dl	0.001	0.045	0.357
Iron	167.9	±	76.0	388.0	0.0	mcg/dl	0.203	0.878	0.127
Total Protein	6.4	±	1.1	8.4	0.0	g/dl	0.002	0.691	0.281
Albumin	3.0	±	0.5	4.1	1.5	g/dl	0.218	0.280	0.046
Alk. Phos.	62.8	±	47.7	269.0	8.0	U/L	0.001	0.407	0.834
Total Billir.	0.1	±	0.3	1.5	0.0	mg/dl	0.360	0.926	0.082
Cholesterol	167.5	±	48.9	438.0	106.0	mg/dl	0.145	0.014	0.776
Trigly.	47.8	±	28.7	214.0	6.0	mg/dl	0.400	0.045	---
SGOT	41.8	±	89.4	999.0	10.0	U/L	0.047	0.333	0.041
LDH	102.9	±	91.2	569.0	13.0	U/L	0.053	0.532	0.947
CPK	81.5	±	81.0	619.0	0.0	U/L	0.001	0.478	0.213

*Mean ±/S.D.

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US Army Foreign Science & Technology
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